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(54) DEAERATION APPARATUS INTEGRAL WITH A SEPARATION CELL EMPLOYED IN A HOT WATER PROCESS FOR EXTRACTING OIL FROM OIL SANDS

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ABSTRACT OF THE DISCLOSURE

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A group (typically, three) of relatively small froth deaerating cells are distributed directly around the periphery of each separation cell below the launders. Thus, deaerated froth, in effect, is obtained directly from the separation cell to obviate the need for downstream equipment and realize improvements in process flexibility, operator convenience, installation cost, and plant floor space utilization. The hot froth provides an effective, close-by head to the pumps which may therefore be smaller and are self primed. Winter restarts after system maintenance are also facilitated.

DEAERATION APPARATUS INTEGRAL WITH A SEPARATION CELL EMPLOYED IN A HOT WATER PROCESS FOR EXTRACTING OIL FROM OIL SANDS

BACKGROUND OF THE INVENTION

This invention relates to the separation of oil from bituminous sands such as Athabasca oil sands. More particularly, the invention relates to a modification to the hot water process for extracting bitumen from oil sands, by which modification deaerated bitumen is produced in a deaeration zone directly adjacent the separation cell to obtain froth which is readily pumpable.

In the hot water process employed for recovering oil from oil sands (also known as tar and bituminous sands), such as presently practiced at the Suncor (formerly GCOS) and Syncrude plants in northern Alberta, the oil sands are mulled and jetted with steam together with a minor amount of hot water at temperatures typically in the range 170°F to 190°F, and the resulting pulp is mixed with hot water and transferred to a separation cell maintained at temperatures from 140°F to 185°F. In the separation cell, sand settles to the bottom as tailings, and oil rises to the top in the form of a froth. An aqueous middlings layer comprising clay, silt and some oil is formed between the sand and froth layers. This basic process may be combined with a scavenger step for further treatment of the middlings layer obtained from the primary separation step to recover additional amounts of oil therefrom.

In recovering bituminous froth utilizing the process disclosed in Canadian Patent No, 841,581 and the hot water separation cell disclosed in Canadian Patent No. 882,667, the froth

is recovered in overflow launders disposed on the upper edge of the extraction cell. Thereafter, the froth flows by gravity into a collection vessel located near the separation cell below the level of the froth collection launders. Often, one collection vessel serves four or more separation cells to provide a central collection means for recovered froth. Froth from secondary scavenger steps can also be collected in this same vessel. Thereafter, the froth is heated and transferred to a centrifuge zone or to other means for effecting demineralization and dehydration. Normally, the froth is diluted with a liquid hydrocarbon before the demineralization and dehydration steps. Methods for accomplishing water and mineral removal from the froth are disclosed in Canadian Patent No. 910,271 and Canadian Patent No. 918,091.

The bituminous froth, as recovered from the hot water separation cell, resembles a liquid foam with poor flow characteristics. The froth is difficult to pump and therefore must be treated to improve its liquid flow characteristics if it is to be handled by centrifugal pumps. The characteristics of the froth particularly detrimental to handling with centrifugal pumps are: (i) high air content and (ii) high viscosity on the order of 7500 centipoise at 150°F.

Canadian Patent No. 630,710 discloses that bituminous froth can be collected and transferred to a deaeration zone where it is heated with steam at subatmospheric pressures to remove air bubbles from the froth. This end can be accomplished by adding the froth to a steam heated oil bath maintained at subatmospheric pressure. The froth is therein diluted with oil and agitated to remove air bubbles from the froth. Although this method improves the froth, transferring the froth to the treatment apparatus disclosed nevertheless renders the process cumbersome and expensive.

Canadian Patent Application Serial Number 338,510, filed October 26, 1979, and entitled "Bitumen Deaeration Process Carried Out in the Separation Cell", by Roy Wood, discloses means for obtaining deaerated froth directly from the separation cell by adding a defoaming agent (such as Dow Corning Silicone 200) to the oil sands feed on a conveyor belt as it flows into the conditioning drum or, alternatively, after the conditioning step in the feed to the separation cell or to the froth launder itself. This process achieves a readily pumpable froth directly from the separation cell, but is somewhat expensive to implement and operate. Additionally, and more importantly, the cumulative effects of long term use of defoaming agents in the hot water process may have adverse effects on the subsequent recovery of bitumen from the sludge layer of the tailings pond or ponds associated with the hot water process as well as the treatment of the sludge layer to meet certain ecological requirements.

Thus, it will be appreciated by those skilled in the art that it would be highly desirable to provide means for deaerating bituminous froth which is simple and inexpensive and which does not bring about long term, possibly detrimental, side effects to the system.

OBJECTS OF THE INVENTION

It is therefore a broad object of this invention to provide an improved hot water process for extracting bitumen from oil sands.

It is a more particular object of this invention to provide improved means for deaerating bitumen froth obtained in a hot water process for extracting bitumen from oil sands such that the froth is readily pumpable and may be more easily subsequently processed into synthetic crude oil.

Still more specifically, it is an object of this invention to provide, in a hot water process for extracting bitumen from oil sands, a froth deaeration system including at least one deaerator box directly adjunct the periphery of each separation cell for receiving bitumen froth from the separation cell overflow launders by gravity feed and pump means proximately situated below the deaeration box for transferring the deaerated froth downstream for further processing.

Thus, in accordance with the present teachings, an improvement is provided in a system for effecting a hot water process for extracting bitumen from oil sands wherein the process includes the steps of forming a mixture of oil sands and water, passing the mixture to a separation cell to form an upper bitumen froth layer, a middlings layer, and a sand tailings layer and recovering the bitumen froth layer by means of an overflow froth launder disposed circumferentially around the separation cell proximate the top thereof. The improvement which is provided comprises providing at least one deaerator box disposed adjacent the separation cell and generally below the launder and conduit means for conducting froth downwardly by gravity flow from the launder to the deaerator box whereby deaerated and more easily pumped froth is obtained from the deaerator box.

DESCRIPTION OF THE DRAWING

The subject matter of the invention is particularly pointed out and distinctly claimed in the concluding portion of the specification. The invention, however, both as to organization and method of operation, may best be understood by reference to the following description in conjunction with the accompanying drawing of which:

Figure 1 is a simplified schematic representation of a hot water process, employing the present invention, for extract-

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ing bitumen from oil sands;

Figure 2 is a top plan view of a practical installation for the present invention, which plan view omits, for clarity, certain steam lines and related structures shown in other Figures;

Figure 3 is an elevational view taken generally along and between the lines 3-3 of Figure 2, but showing additional structure;

Figure 4 is an elevational view, partially cutaway, taken generally along and between the lines 4-4 of Figure 2, but showing additional detail;

Figure 5 is a top plan view similar to Figure 1, but omitting, for clarity, certain structure included in Figure 1 and showing other structure not included in Figure 1;

Figure 6 is a partially cutaway sectional view along the lines 6-6 of Figure 2; and

Figure 7 is a partially cutaway fragmentary view taken along the lines 7-7 of Figure 2.

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DETAILED DESCRIPTION OF THE INVENTION

Referring now to Figure 1, mined oil sands are fed into the system through a line 10 and are carried by a conveyor 9 to a conditioning drum or muller 11. Water is fed to the muller by a line 12, and steam is introduced thereto through line 13. The total water so introduced in liquid and vapor form is a minor amount based on the weight of the oil sands processed. The conditioning drum 11 is provided with suitable kneading or mixing means (not shown) to give the desired mulling action. Enough steam is introduced through line 13 to raise the temperature in the conditioning drum to within the range of 130-210°F and preferably to above 170°F. Mulling of the oil sands produces a pulp which then passes from the conditioning drum as indicated by line 14 to a screen indicated at 15. The purpose of the screen 15 is to remove from the oil sands pulp any debris, rocks, or oversize lumps as indicated generally at 16. The conditioned oil sands pass from the screen 15 to a pulp box 17 which serves as a zone for diluting the pulp with additional water before passage to a primary separation zone 15. Hot water from a heater 27 is passed through a line 19 to pulp box 17, and additional steam is fed thereto through a line 20, if necessary, to maintain the range of 130-210°F and preferably above 170°F. Also, a middlings stream, which is withdrawn from the primary separator 18, may be recycled through lines 21 and 19 to the pulp box. This recycle stream serves to provide sufficient liquid to flood the oil sands pulp from the pulp box and effect transfer of the pulp to the separator. Another function of the recycle stream is to cause dispersion of the pulped material as it is fed into the separation zone 18. However, such recycling of middlings is not essential in all cases, particularly when the clay content of the tar sands is high. In this event, a relatively high rate

of fresh water introduction through heater 27 can be employed to compensate for the high clay content while the correspondingly high rate of transfer of middlings layer through line 26 as hereinafter described can be maintained. Under these circumstances, recycling of the other stream of middlings through lines 21 and 19 to pulp box 17 is not required.

Modifications that may be made in the process as above described include sending a minor portion of the middlings recycle stream from line 21 through a suitable line (not shown) to muller 11 to supply all or a part of the water therein other than that supplied through condensation of the steam which is consumed. Also, if desired, a stream of the middlings recycle can be introduced onto the screen 15 to flush the pulp therethrough and into pulp box 17.

Separation zone 18 may comprise a large cylindrical or rectangular tank, or battery of tanks, which may, if desired, be provided with heating coils 22 for maintaining a temperature in the range of 130-210^{o}F, and preferably above 170^{o}F. A launder 4 about the upper periphery of a separator collects froth as it floats to the top of the separator and flows over the upper lip thereof. A sand tailings removal line having a star valve 24 or any other suitable control discharge means is provided at the bottom of the separator 18. Separator 18 also has an intermediate withdrawal line 26 through which a stream of middlings layer is removed in addition to that recycled through line 21.

Because of the high air content in the froth which flows into the lauders 4, the froth is difficult to pump. Thus, according to the present invention, a deaerator box 1 affixed to the separator 18 receives froth from the launders by gravity flow through lines 2. Steam is injected into the deaerator through a line 3 to promote deaeration of the froth as more fully described

below. The deaerated froth then flows through a line 5 by gravity into a suction tank 6 from which it is withdrawn through a line 7 by a pump 8. The deaerated froth is conveyed downstream through a line 23 for further processing.

The middlings layer obtained in separation zone 18 will contain most of the silt and clay which was present in the oil sands in their natural state. In order to prevent the build up of clay in the system, it is necessary to continually discard some of the middlings layer and supply enough water in the conditioning operations to compensate for that so discarded. The rate at which the middlings needs to be removed from the system depends upon the content of clay and silt present in the oil sands feed, and this will vary from time to time as the content of these fines varies. If the clay and silt content is allowed to build up in the system, both the density and the viscosity of the middlings layer will increase. Concurrently, with such increase, an increase in the proportions of both the oil and the sand retained by the middlings will occur. If the clay and silt content is allowed to build up too high in the system, effective separation will no longer occur, and the process will become inoperative. Hence, it is important to regulate the withdrawal of middlings through line 26, and the addition of fresh water to the system to compensate for water thus removed, in a way that will keep the separation step operating properly. However, when this separation step is oeprating in an optimum manner, the middlings layer withdrawn through line 26 will contain a substantial amount of oil which did not separate. Hence, the middlings layer withdrawn through line 26 is, for purpose of description, herein referred to as "oil-rich middlings."

The rate of addition of fresh water to the system and the rate of removal of middlings layer from separation zone 18

through line 26 are regulated in accordance with either the density or the viscosity of the middlings layer or both. When density is used for the control, such addition and removal are carried out so that the middlings density is maintained in the range of 1.03-1.50 gm/cc, more preferably 1.10-1.20 gm/cc. It is preferred, however, to utilize viscosity to effect the control in which case the water addition and removal are carried out to maintain the middlings viscosity in the range of 0.5 to 10 centipoise, more preferably 0.6 to 3.0 centipoise. Periodic or continuous measurements of either viscosity or density for the middlings phase can be made, and the removal of middlings through line 26 and corresponding addition of fresh water to the system can be regulated in accordance with the measured values to maintain the value within the range desired. Whenever either density or viscosity tends to become higher than is desired, an increase is made in the rate of middlings removal and corresponding rate of fresh water addition; and if density or viscosity values tend to become too low, decreases in these removal rates are effected.

As previously mentioned, the middlings layer withdrawn through line 26 will still contain a substantial amount of oil even though the separation step is operated under optimum conditions. The amount of oil remaining in the middlings layer appears to be more or less related to the percentage of clay and/or silt present in the oil sands being processed, varying directly with the amount of clay and/or silt present. For example, typical oil recovery values for the froth from oil sands in which 15% of the mineral matter is less than 44 microns and from sands in which 25-30% is less than this size are, respectively, 85% and 60%. For commercial operation, it is highly desirable to obtain increased recoveries over such values, and

this is particularly true when the tar sands mined contain a relatively high proportion of clay and silt components. In a large size commercial operation, an increase of oil recovery of even a few percentages values can amount to a large volume of additional oil per day.

To carry out such secondary recovery, the oil-rich middlings stream withdrawn from separator 18 through line 26 is sent to a scavenger zone 29 wherein an air flotation operation is conducted. The processing conducted in scavenger zone 29 provides a controlled zone of aeration in the flotation cell at a locus where agitation of the middlings is being effected so that air becomes dispersed in the middlings in the form of small bubbles. Figure 1 illustrates a flotation cell of the subaeration type wherein a motorized rotary agitator 30 is provided and air is fed thereto in controlled amount as by means of line 31. Alternatively, the air can be sucked in through the shaft of the rotor. The rotor effects dispersion of the air in the middlings. This air causes the formation of additional oil froth which passes from the scavenger zone 29 through line 32 and thence to line 23 for further processing in admixture with the froth derived from the primary separation in zone 18. An oil-lean middlings stream is removed from the bottom of scavenger zone 29 via line 33 and is discarded from the process. The oil-lean middlings contains a substantial proportion of the clay and silt components that were present in the original tar sands, and discarding thereof from the process prevents the build up of this fines material in the separation zone 18. The amount so discarded is such as to maintain the viscosity and density of the oil-rich middlings in zone 18 within the ranges as specified hereinbefore.

The mixed froths from lines 23 and 32 will contain some water and an appreciable amount of the finer mineral matter that was present in the tar sands. Generally this material will be sent to a processing zone (not shown) wherein the water and mineral matter are removed. This can be achieved by diluting the froth with naphtha and treating the mixture in an electrostatic precipitator or in centrifuges to effect dehydration and demineralization.

A practical installation employing the froth deaerating system of the present invention is shown in Figures 2-7. Each of an array of four separation cells 18a, 18b, 18c, 18d, carries, about its periphery, three deaeration boxes: $1a_1$, $1a_2$, $1a_3$; $1b_1$, $1b_2$, $1b_3$; $1c_1$, $1c_2$, $1c_3$; and $1d_1$, $1d_2$, $1d_3$; respectively. Downwardly inclines pipes 50 and 51 lead, respectively, from deaerator boxes $1a_1$ and $1a_2$ to deaerator box $1a_3$ from which line 52 tees (with a corresponding line 55) into a line 56 through which deaerated bitumen is conveyed to a suction tank 57. Downwardly inclined lines 53 and 54 lead, respectively, from deaerator boxes $1b_1$ and $1b_2$ to deaerator box $1b_3$ from which line 55 extends.

Similarly, downwardly inclined lines 58 and 59 from deaerator boxes $1c_1$ and $1c_2$ feed deaerated froth to deaerator box $1c_3$, and downwardly inclined lines 61 and 62 feed deaerated froth from deaerator boxes $1d_1$ and $1d_2$ to deaerator box $1d_3$. The deaerated froth from the deaerator boxes $1c_3$ and $1d_3$ flow, respectively, through pipes 60 and 63 to pipe 64 which feeds suction tank 65.

Deaerated froth is withdrawn from the suction tank 57 by parallel pumps 66 and 67 which feed output line 68. Similarly, deaerated froth is withdrawn from suction tank 65 by parallel pumps 69 and 70 which feed output line 71. The output lines 68

and 71 merge into the primary output line 72 which is the counterpart of the line 23 shown in the simplified schematic representation of Figure 1.

As best shown in Figure 4, sparge steam for carrying out the deaerating process within the deaerator boxes (deaerator box $1d_1$ in Figure 4) is introduced near the deaerator box bottom at inlet 73 which is coupled to a supply steam header (not shown in Figure 4) as will be described in more detail below. The sparge steam moves upwardly in the deaerator boxes and is collected in a steam vent header system as illustrated in Figure 5 in which the various steam vent pipe branches 74 feed steam vented from the deaerator boxes to a common steam vent output line 75.

The flow paths of the fluid within a typical deaeration box ($1d_1$) may best be understood by reference to Figures 6 and 7. Bituminous froth which has overflowed from the separation cell 18d into the launder 81 (illustrated in the simplified schematic of Figure 1 as launder 4) passes through conduit 82 to distribution pipe 83 situated within the deaerator box $1d_1$ near the top. The distribution pipe 83 has a series of openings 84 distributed along its length in order to spread the bitumen stream laterally and permit it to extend as a more or less uniform sheet across the full width of the deaerator box $1d_1$. As the bitumen stream descends, it cascades from tier to tier of a shed deck 85. Steam from a header 86 is distributed across the width of the deaerator box $1d_1$ near the bottom by a perforated pipe 87. As the steam upwardly through the distribution box $1d_1$ it encounters the sheet of bitumen froth cascading downwardly over the individual elements of the shed deck and shears away the air from the bitumen stream. Thus, the froth reaching the bottom of the deaerator

box 1d is substantially purged of air and is withdrawn through line 61 as a pumpable liquid ready for downstream processing.

One presently preferred configuration for the shed deck 85 is illustrated in Figure 6. The shed deck 85 comprises alternate downwardly slanted elements 88 and 89. The elements 89 extend from each side of the deaerator box interior wall and slope downwardly toward the center. The elements 89 are centrally disposed and have a roof-like configuration sloping downwardly toward the inner walls of the deaerator box $1d_1$ from a central peak. Thus, it will be understood that the froth introduced into the top of the deaerator box $1d_1$ cascades back and forth between the alternate elements 88 and 89 to provide maximum expose of the froth to the stripping action of the steam moving upwardly through the deaerator box.

While the principles of the invention have now been made clear in an illustrative embodiment, there will be immediately obvious to those skilled in the art many modifications of structure, arrangements, proportions, the elements, materials, and components, used in the practice of the invention which are particularly adapted for specific environments and operating requirements without departing from those principles.

THE EMBODIMENTS OF THE PRESENT INVENTION IN WHICH AN EXCLUSIVE PROPERTY OR PRIVILEGE IS CLAIMED ARE DEFINED AS FOLLOWS:

1. In a system for effecting a hot water process for extracting bitumen from oil sands, which process includes the steps of:

a) forming a mixture of oil sands and water;

b) passing said mixture to a separation cell to form an upper bitumen froth layer, a middlings layer, and a sand tailings layer; and

c) recovering said bitumen froth layer by means of an overflow froth launder disposed circumferentially around said separation cell proximate the top thereof;

the improvement comprising the provision of:

i) at least one deaerator box disposed adjacent said separation cell and generally below said launder; and

ii) conduit means for conducting froth downwardly by gravity flow from said launder to said deaerator box

whereby deaerated, and therefore more easily pumped, froth is obtained from said deaerator box.

2. The system of Claim 1 in which a plurality of generally equally distributed deaerator boxes are disposed about the circumference of said separation cell.

3. The system of Claim 2 in which said deaerator boxes are affixed to and supported by said separation cell.

4. The system of Claim 1 in which each said deaerator box includes distribution means in its upper region for receiving froth from said launders and distributing the froth laterally within said deaerator box such that the froth flows downwardly through said deaerator box as a sheet.

5. The system of Claim 4 in which the interior of said deaerator box includes a plurality of shed deck elements adapted to direct said froth sheet back and forth as it cascades downwardly.

6. The sytem of Claim 5 which includes injection means for introducing and laterally distributing stripper steam withinin said deaerator box in the lower region thereof and vent means in the upper region thereof for collecting and venting said stripper steam.

7. The system of Claims 4, 5, or 6 in which a plurality of generally equally distributed deaerator boxes are disposed about the circumference of said separation cell.

8. The system of Claims 4, 5, or 6 in which a plurality of said deaerator boxes are affixed to and supported by said separation cell.

9. The system of Claims 4, 5, or 6 in which a plurality of said deaerator boxes are affixed to and supported by said separation cell and are generally equally distributed about the circumference thereof.

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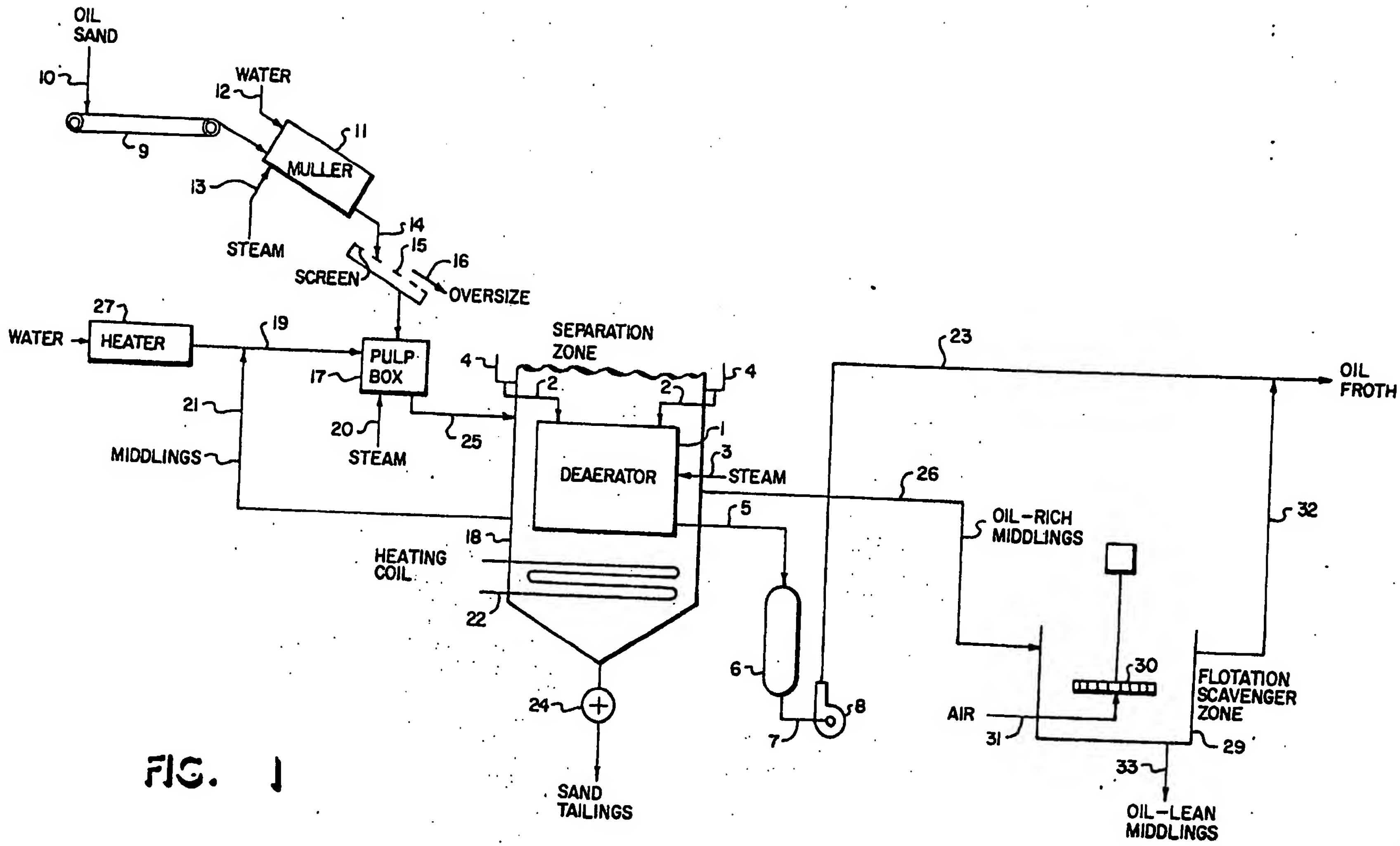

FIG. 1

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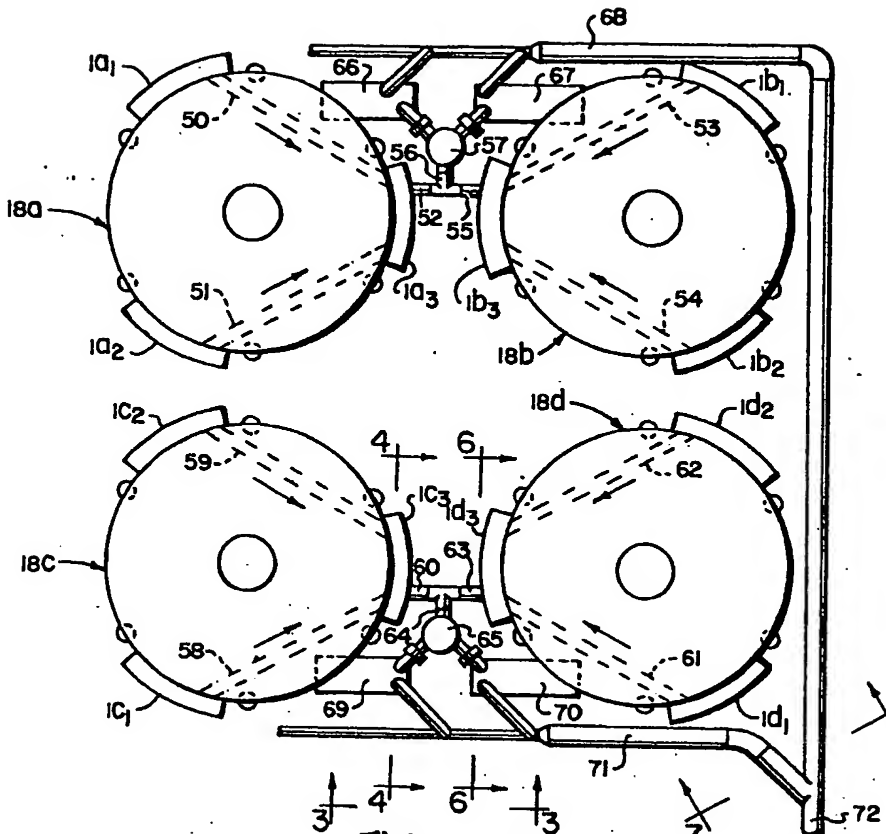

FIG. 2

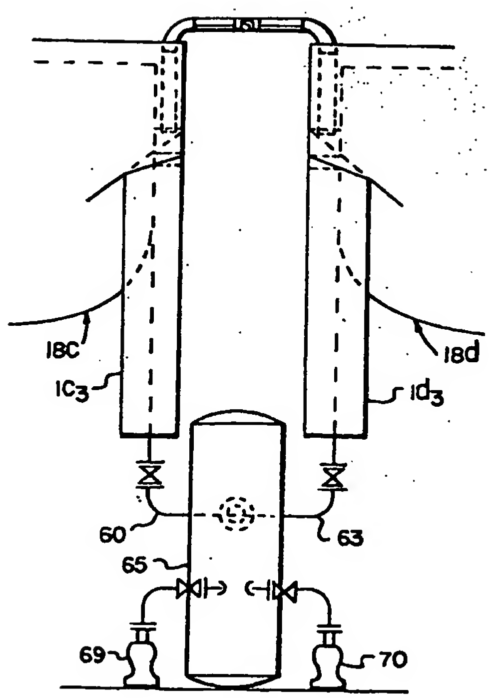

FIG. 3

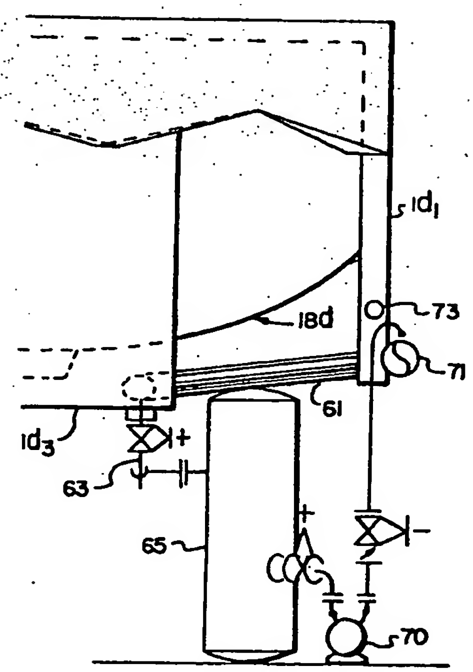

FIG. 4

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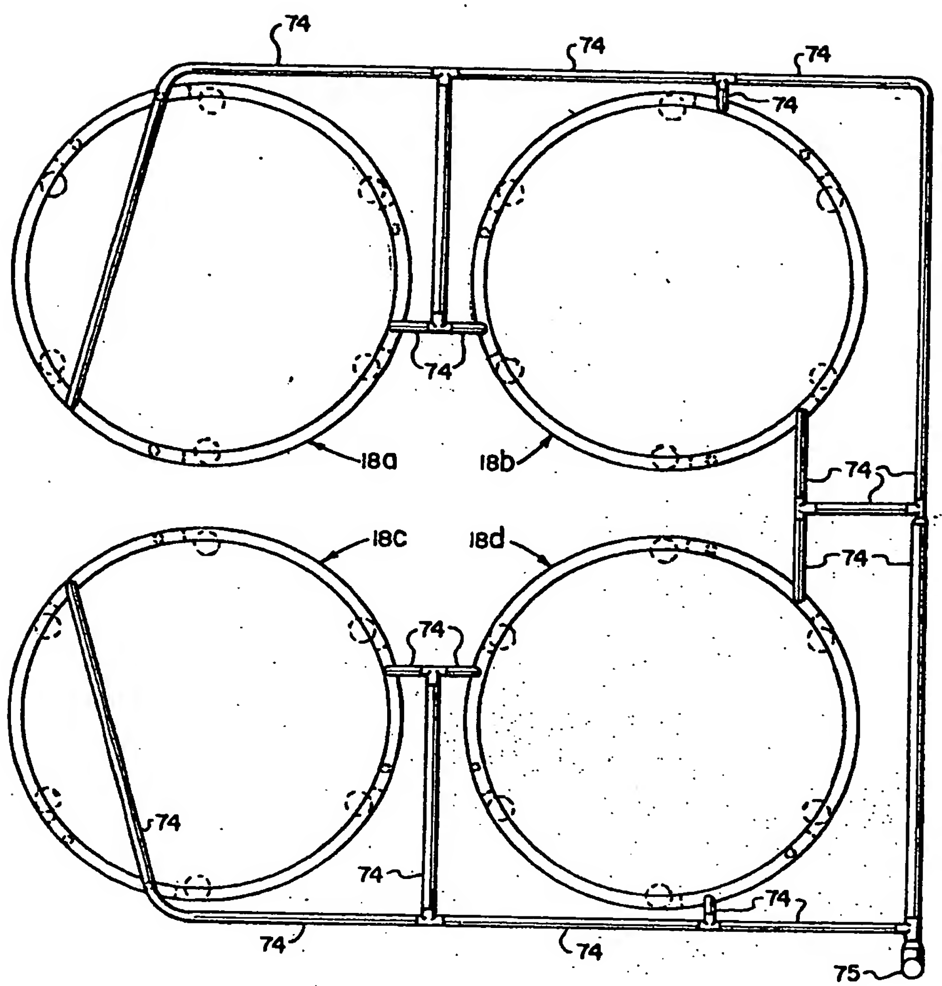

FIG. 5

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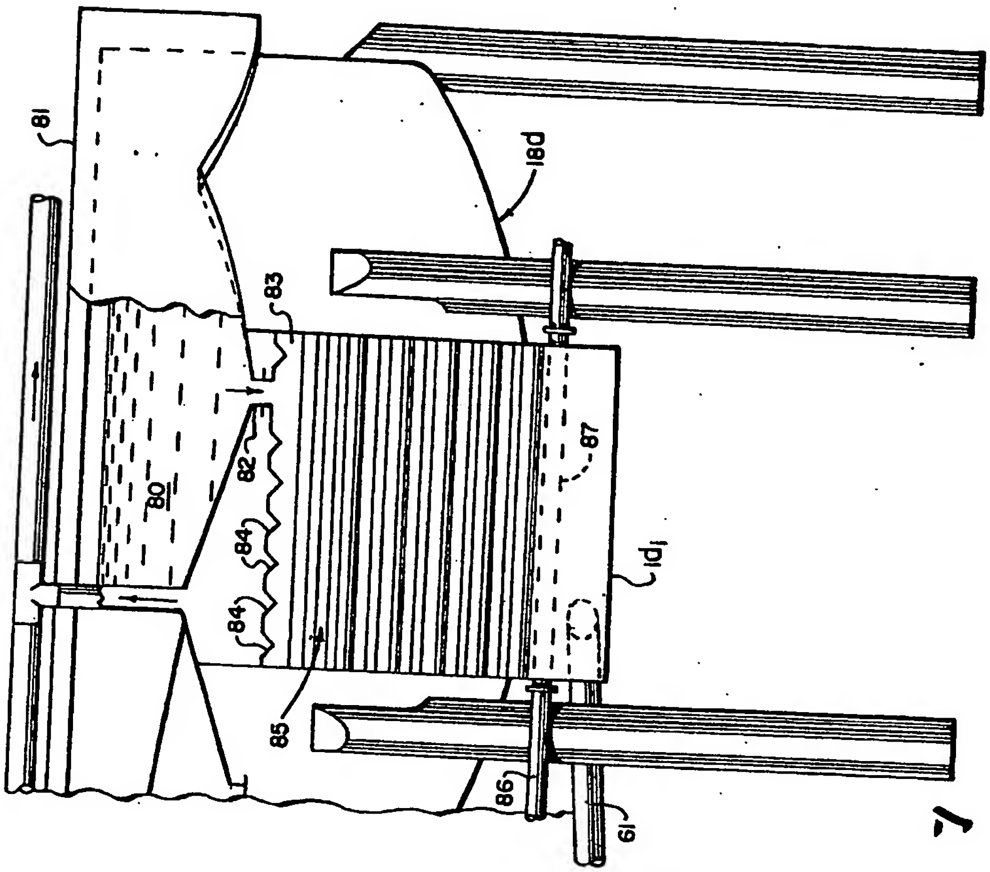

FIG. 7

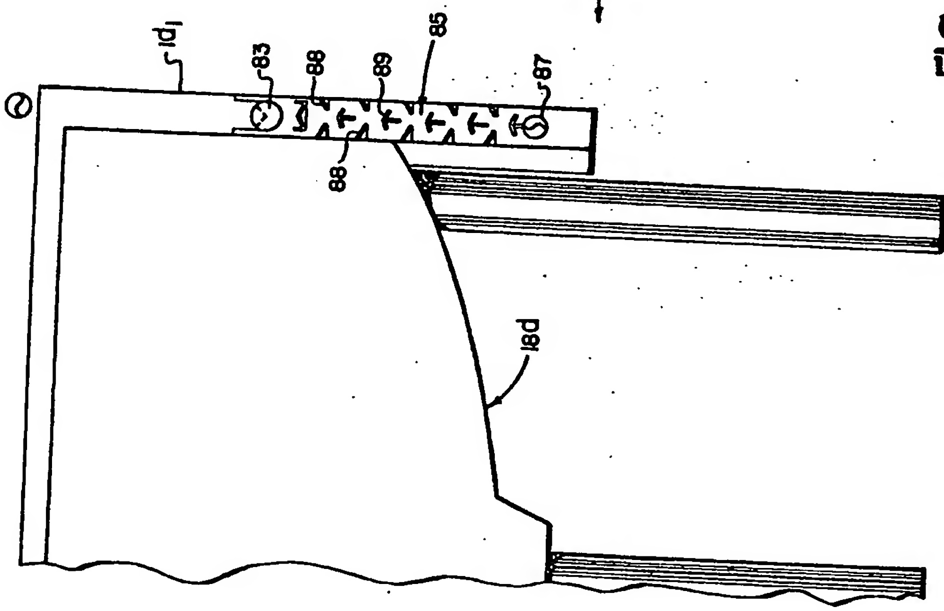

FIG. 6

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(54) MINERAL BREAKERS

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ALAN POTTS

ABSTRACT

MINERAL BREAKERS

A mineral breaker having a pair of side by side breaker drums which are spaced laterally from one another and arranged to rotate in opposite directions, each drum having a plurality of breaker teeth arranged in circumferentially extending groups of teeth spaced along each drum with the groups of teeth on one drum being positioned so as to extend between the groups of teeth on the other drum.

MINERAL BREAKERS

The present invention relates to mineral breakers in particularly, to mineral breakers for use in coal mining for ensuring maximum sizing of coal.

According to the present invention there is provided a mineral breaker having a pair of side by side breaker drums which are spaced laterally from one another and arranged to rotate in opposite directions, each drum having a plurality of breaker teeth arranged in circumferentially extending groups of teeth spaced along each drum with the groups of teeth on one drum being positioned so as to extend between the groups of teeth on the other drum.

Reference is now made to the accompanying drawings, in which:

Figure 1 is a plan view, partly in section, of a mineral breaker according to the present invention;

Figure 2 is a side view of the mineral breaker shown in Figure 1;

Figure 3 is a sectional view taken along line III-III in Figure 2;

Figure 4 is a similar view to that of Figure 3 of a different embodiment according to the present invention;

Referring initially to Figures 1 to 3, a mineral breaker 10 includes a main frame 11, which in use is capable of being sited over a conveyor for depositing sized material onto the conveyor which then transports the sized mineral away. The frame 11 houses a pair of breaker drums 14 which are located within a chamber 11a defined by side walls 11b of the housing and end support walls 50,51. Each of the drums 14 is fixedly mounted on shafts 15 and 16 respectively. Each drum is provided with a plurality of breaker teeth 17 which are arranged in circumferentially extending groups of teeth, with the groups on one drum being positioned so as to extend between the groups on the other drum.

Both shafts 15,16 are rotatably supported at each end in bearing assemblies 19,20 respectively. Each pair of bearing assemblies 19,20 are respectively mounted within bearing seats 52,53 formed in end support walls 50,51 respectively. The end support walls 50,51 are each composed of two separate halves 50a, 50b and 51a,51b respectively, each half being secured to the side walls of the housing by bolts 54. Thus by separating adjoined halves it is possible to remove the respective bearing assemblies from the end support walls.

Shaft 15 is drivingly connected via a drive coupling 28 to an electric motor and reduction gear box assembly 30 which is bolted to an end plate 58 of the housing 11. Preferably the drive coupling 28 is of similar construction to that disclosed in U.K. Patent application 40511/78 published on May 21, 1980 under Publication No. 2033538.

Shafts 15 and 16 are drivingly connected to one another by means of a pair of meshing gears 35 so that the drums 14 rotate in opposite directions. As shown in Figure 3 the angular position of the teeth on one drum in relation to those on the other drum is preferably arranged so that teeth on one drum extend between the circumferential spacing between teeth on the other drum. This relative angular position is maintained during operation by the meshing gears 35. It will be appreciated that the relative angular position between teeth on the drums may be adjusted as desired by changing the relative angular position of meshing gears 35. By changing the relative angular positions of the teeth on the drums 14 it is possible to adjust the breaker so as to produce sized material of a predetermined size.

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The breaker teeth 17 are of a robust construction, as seen in Figures 3 and 4, and are constructed so as to be capable of breaking mineral which the breaker is intended to size. According, due to the interrelationship of the breaker teeth 17 all oversized mineral passing between the

breaker drums 14 is broken to provide sized mineral which is of a predetermined maximum size.

The shape of the breaker teeth 17 facilitates breaking of the oversized mineral in that a recess 59 is provided between adjacent rear faces 60 of teeth 17, the rear face of each tooth 17 being defined by a ridge 61 which in cross-section is arcuate as shown in Figures 3 and 4. The width of ridge 61 is chosen bearing in mind the working conditions of the breaker. Accordingly oversized material will initially be seated across the ridges 61 of one or more adjacent teeth 17 on one drum and then on rotation of the drums, the front face 62 of teeth 17 on the other drum will engage the oversized material seated on the ridges 61. The oversized mineral will therefore be subjected to opposed loadings along its length thus causing it to fracture.

As seen in Figures 3 and 4, the front face 62 of each tooth 17 is inclined so as to define with an acute enclosed angle α with the tangent to the circumference of the drum at the point of intersection of the face 62 with the periphery of the drum. It will be appreciated that angle α may be varied as desired to suit working conditions of the mineral breaker.

In the embodiment of Figures 1 to 3, the teeth 17 on each drum 14 are formed separately to the drum 14. Thus sets of teeth 17 are cast together to form an elongate toothed strip 17*a* which includes a body portion 17*b* and teeth 17 projecting therefrom. The body portion 17*b* is provided with a rib 17*c* which extends longitudinally along same side of the body portion 17*b* as that from which the front faces 62 of teeth 17 are located.

Each drum 14 is provided with longitudinally extending channels 70 spaced circumferentially from one another. Each channel 70 has a bottom wall 70*a* against which the bottom face 17*d* of the body portion 17*b* abuts in use. Each channel also has a groove 71 for housing rib 17*c* as seen in Figure 3. Each drum 14 is provided

with bolt studs 75 which are anchored in the drum and project outwards into channel 70. The strips 17a are provided with apertures 80 and nut accomodating recesses 81 for securing each strip to the drum. For the sake of simplicity, apertures 80 and recesses 81 have been omitted from Figure 2, their location being identified by crosses A. As seen in Figure 2, two strips 17a are provided in each channel 70. It will be appreciated that toothed drums of varying lengths may easily be constructed using one or more strips 17a per channel 70.

The method of securing the strip 17a to the drums 14 described above is particularly advantageous since removal of the strips is relatively simple by removal of nuts 76 whilst, in use, loadings applied to the front faces 62 of the teeth are transmitted to the drum via ribs 17c and co-operating grooves 71 and the bottom face 17d of the body portion 17b and the bottom wall 70a of channel 70. Thus in use, bolt studs 75 and nuts 76 are not loaded by the breaking operation of the drums.

It is to be noted that in Figure 3 all teeth 17 are formed on strips 17a and that for the sake of simplicity only one strip 17a is shown.

In the embodiment of Figure 4, all parts of the breaker are the same as those described in respect of the embodiment of Figures 1 to 3 apart from the drum construction. Thus, in Figure 4, teeth 17 are formed integrally with drums 14 instead of being formed on strips 17a.

I CLAIM:

1. A mineral breaker having a pair of side by side breaker drums which are spaced laterally from one another and arranged to rotate in opposite directions, each drum having a plurality of breaker teeth arranged in circumferentially extending groups of teeth spaced along each drum with the groups of teeth on one drum being positioned so as to extend between the groups of teeth on the other drum, the angular position of teeth on one drum in relation to those on the other drum is arranged so that teeth on one drum extend between the circumferential spacing between the groups on the other drum, the teeth on one drum cooperating with teeth on the other drum to place oversized mineral under tensile loadings to effect breakage of the oversized mineral.

2. A mineral breaker according to claim 1, wherein each tooth on each drum is provided with a ridge projecting rearwardly, in the direction of rotation.

3. A mineral breaker according to claim 2, wherein the ridge of each tooth is arcuate in cross-section.

4. A mineral breaker according to claim 1, 2 or 3, wherein the leading face of each tooth on each drum is substantially planar.

5. A mineral breaker according to claim 1, 2 or 3, wherein the teeth on each drum are integrally formed therewith.

6. A mineral breaker according to claim 1, wherein the teeth on each drum are releasably connected to the drum.

7. A mineral breaker according to claim 6, wherein the teeth are formed as part of elongate toothed strips, the strips being releasably connected to a respective drum so as to extend along the length of the drum.

8. A mineral breaker according to claim 7, wherein each strip has a body portion from which said teeth project and a rib projecting from the leading side of the body portion, the drum having longitudinally extending channels for receiving the body portion and a recess formed in the leading side wall of each channel for accommodating said rib.

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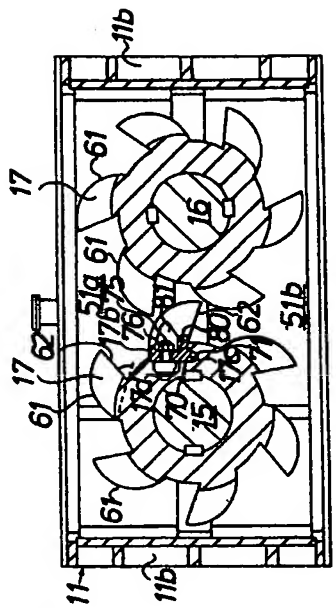

Fig. 3

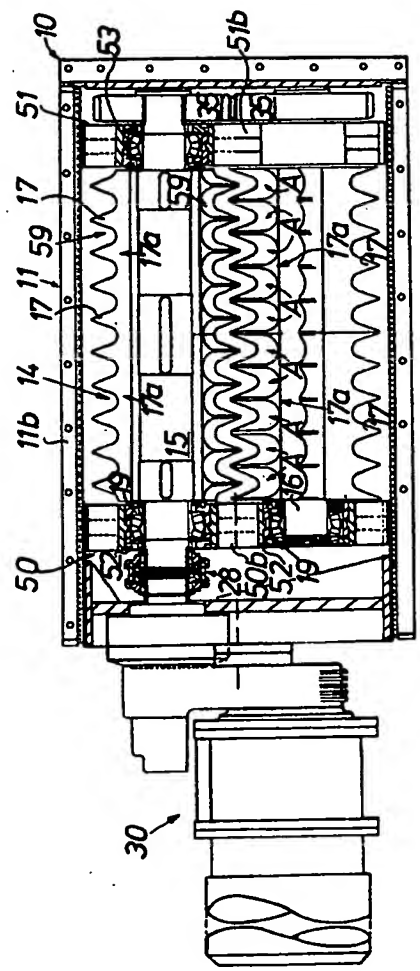

Fig. 1

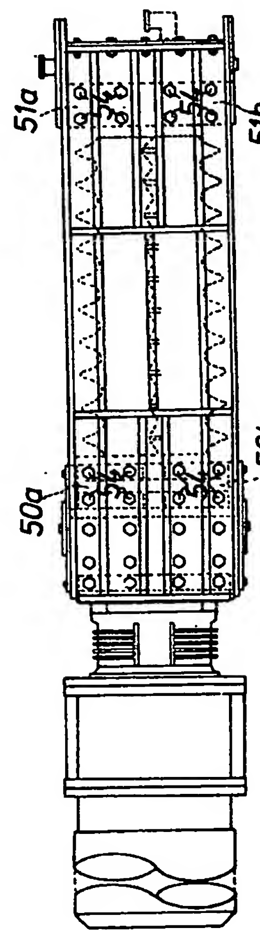

Fig. 2

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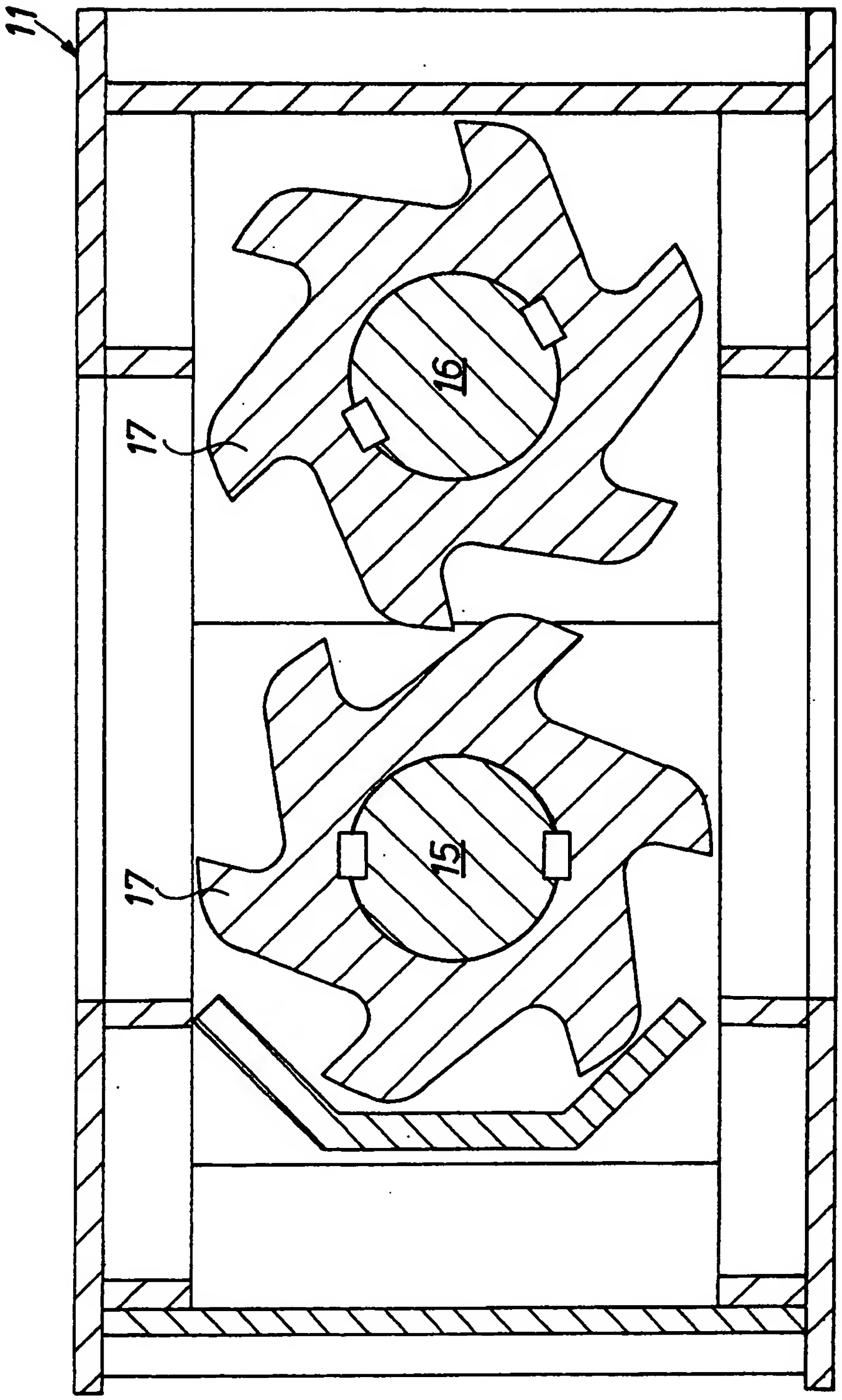

Fig. 4

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